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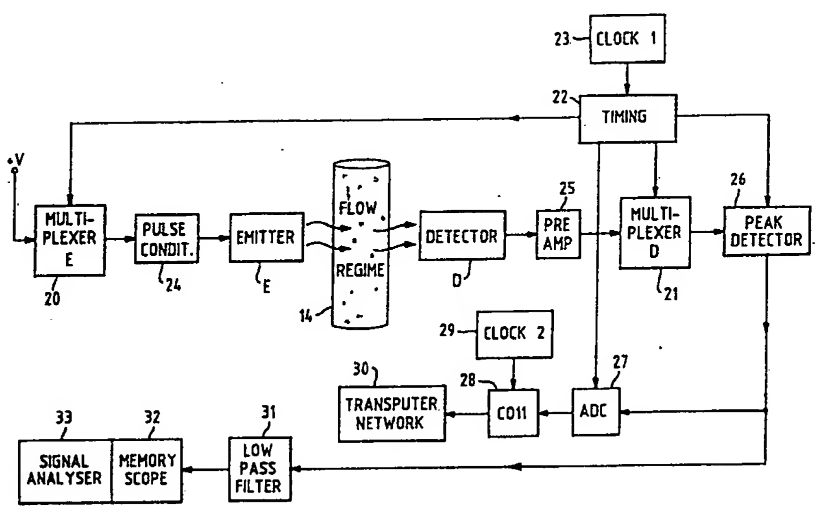

(57) Abstract

The invention provides a method and apparatus for monitoring flow of a fluid having at least two components, by transmitting a train of signal pulses, preferably of visible or near-visible light from one or more light-emitting diodes or laser diodes, in at least one beam transversely through the fluid flow, detecting the pulses after attenuation thereof by transmission through the fluid and deriving a train of output pulses corresponding to the detected attenuated pulses, and deriving from the output signals data relating to the configuration of the flowing fluid where subjected to the signal pulses. The train of output pulses may be subjected to a frequency analysis to establish the frequency spectrum thereof and thereby identify the type of flow regime of the fluid. If the signal pulses are transmitted in a plurality of at least approximately collimated signal beams across a transverse cross-section of the flowing fluid, the output signals corresponding to the signal beams as detected after attenuation during passage through the fluid may be stored and used for deriving therefrom tomographic data relating to the instantaneous spatial configuration of the flowing fluid at the said cross-section. Such data may be obtained relating to sequences of timed reconstructed cross-sectional images for two spaced-apart locations, and data relating to an image for one of the locations compared for identity or near-identity with data relating to images of the other of the locations, the time lapse between the timings of two corresponding images being utilised as a measure of the transit time of the fluid between the two locations and hence of the flow velocity.

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TOMOGRAPHIC MONITORING OF FLUID FLOWS

This invention relates to the monitoring of flow of a fluid through a pipe or duct, particularly in relation to a fluid having two, or perhaps more, components which may be non-uniformly or irregularly distributed in the body of the flowing fluid.

The invention may find application in the oil extraction industry, for example for monitoring and evaluating the relative proportions of oil and water in a mixture flowing through a pipe, as well as in other process industries such as pharmaceuticals, fermentation and in mixing processes, in which identification of the type of flow regime or a knowledge of cross-sectional information regarding gas or liquid flow rates, bubble-size distributions, rates of mixing and other process parameters may be very useful and commercially valuable.

It is an object of the invention to provide a method and apparatus for monitoring the flow of a non-uniform fluid through a pipe or duct and providing information regarding the instantaneous spatially distributed composition, and/or the type of flow regime, of the fluid flowing through a cross-sectional transverse section of the flow.

According to one aspect of the invention there is provided a method of monitoring flow of a fluid having at least two components, comprising transmitting a train of signal pulses in at least one beam transversely through the fluid flow to be monitored, detecting the pulses after attenuation thereof by transmission through the fluid and deriving a train of output pulses corresponding to the detected attenuated pulses, and deriving from the output signals data relating to the configuration of the flowing fluid where subjected to the signal pulses.

One such method according to the invention includes the step of performing a frequency analysis on the train of output pulses to establish the frequency spectrum thereof and thereby identify the type of flow regime of the fluid.

In another such method according to the invention, the signal pulses are transmitted in a plurality of at least approximately collimated signal beams across a transverse cross-section of the flowing fluid, and the method includes the further steps of detecting the signal beams after attenuation thereof during passage through the fluid and deriving output signals related to the attenuated signals received, storing the output signals and deriving therefrom tomographic data relating to the instantaneous spatial configuration of the flowing fluid at the said cross-section thereof.

The invention further provides a method of monitoring the velocity of a flowing fluid, comprising the steps of carrying out, repeatedly, at each of two transverse cross-sections of the fluid at two locations spaced from one another in the direction of flow, the method last referred to, including deriving and storing output signals and tomographic data derived therefrom relating to sequences of timed reconstructed cross-sectional images for the two locations, recognising identity or near-identity between data relating to an image for one of the locations and data relating to an image of the other of the locations, and establishing the time lapse between the timings of the two corresponding images as a measure of the transit time of the fluid between the two locations and hence of the flow velocity.

The signal pulses transmitted through the fluid in carrying out any of the methods according to the invention are preferably pulses of visible or near-visible light, which may be produced by the use of light-emitting diodes or laser diodes.

According to a further aspect of the invention there is provided fluid flow monitoring apparatus comprising means for transmitting a train of signal pulses in at least one beam transversely through a flow of fluid to be monitored, means arranged to detect the pulses after attenuation thereof by transmission through the fluid and to provide a train of output pulses related to the attenuated pulses received, and means for

deriving from the output signals data relating to the configuration of the flowing fluid.

One form of such monitoring apparatus according to the invention comprises frequency analyser means arranged to analyse the train of output pulses and establish the frequency spectrum thereof, thereby to identify the type of flow regime of the fluid.

Another embodiment of monitoring apparatus according to the invention comprises a plurality of means for transmitting at least approximately collimated signals across a transverse cross-section of a pipe or duct containing a flowing fluid and a plurality of signal detector or sensor means arranged to detect said signals after attenuation thereof during passage through the fluid and to provide an output signal related to the attenuated signal received, multiplexing means arranged to scan the detector means sequentially and supply the said output signals therefrom to data storage means, and transputer means connected to receive and arranged to process the data stored in the data storage means and derive therefrom tomographic data relating to the instantaneous spatial configuration of the flowing fluid at the said cross-section of the pipe or duct.

According to yet another aspect of the invention there is provided apparatus for monitoring the velocity of a fluid flowing through a pipe or duct, comprising, at each of two locations spaced from one another lengthwise of the pipe or duct, a respective plurality of means for transmitting at least approximately collimated signals across a transverse cross-section of the pipe or duct and a respective plurality of signal detector or sensor means arranged to detect said signals after attenuation thereof during passage through the fluid and to provide output signals related to the attenuated signals received, multiplexing means arranged to repeatedly scan the detector means sequentially and supply the said output signals therefrom to data storage means, transputer means connected to receive and arranged to process the data stored in the data storage means and derive therefrom tomographic data relating to

sequences of timed reconstructed cross-sectional images for the two locations, and means for comparing, and recognising identity or near-identity between, data relating to an image for one of the locations and data relating to an image for the other of the locations and for establishing the time lapse between the timings of the two corresponding images as a measure of the transit time of the fluid between the two locations and hence of the flow velocity.

The invention and preferred embodiments and features thereof will be more fully explained and understood by reference to the accompanying drawings, in which :-

Figure 1 is a schematic cross-sectional view of a pipe or duct containing a flowing fluid, together with an optical signal transmitter or emitter and an associated optical detector;

Figure 2 is a diagrammatic representation of a pipe or duct with a first arrangement of an array of optical emitters and corresponding optical detectors;

Figures 3 and 4 are diagrammatic representations similar to Figure 2 but illustrating two further arrangements of optical emitters and detectors;

Figure 5 is a diagrammatic representation of a pipe or duct having a first array of emitters and detectors as shown in Figure 2, together with a second array of emitters and detectors disposed transversely to the first array;

Figure 6 is similar to Figure 5, but showing three arrays of emitters and detectors with all the arrays angularly displaced from one another;

Figure 7 represents a timed-interval voltage pulse applied to one of the optical signal emitters and a corresponding output signal provided by a corresponding detector;

Figure 8 is a schematic diagram of monitoring apparatus according to the invention and including signal emitters and sensors associated with a pipe or duct, multiplexer means

arranged to scan the signal sensors sequentially, and transputer means;

Figure 9 is a diagram showing the forms and interrelationships of pulses and waveforms occurring in the apparatus shown in Figure 8; and

Figure 10 is a schematic longitudinal sectional view of a pipe or duct containing a flowing fluid, together with two arrays of emitters and detectors disposed in respective cross-sectional planes of the pipe which are spaced from one another in the longitudinal direction of the pipe.

In order to simplify the data processing which is involved in carrying out the invention, thereby minimising the processing time required and enabling near real-time imaging to be achieved, the signals transmitted through the fluid to be monitored and then detected are provided in the form of at least approximately collimated beams of visible or near-visible light so that each beam, from a particular transmitter or emitter, can be received by a corresponding detector or sensor, appropriately positioned. Thus, as shown in Figure 1 by way of illustration, a light-emitting diode (LED) 11 and a coupling lens 12 constitute a signal emitter which transmits a collimated light beam 13 through a transparent wall of a circular-section pipe or duct 14 and a fluid 15 flowing through it, and the beam is then focussed by a lens 16 on to a photodiode 17 which forms therewith a sensor or detector for the beam 13. The fluid 15 may be crude oil, with a random inclusion of droplets (or larger bodies) of water or other contaminant 15', and since crude oil is semi-transparent to certain parts of the infra-red spectrum the LED 11 may then be one which emits IR radiation at a wavelength which corresponds to a window in the transmission spectrum of the oil and to which the pipe 14, which may be of suitable glass, is also transparent.

In practice, in carrying out the invention, a plurality of signal emitters and signal detectors are provided, in pairs. Thus, in Figure 2, an array of eight emitters E1 to E8 are arranged to provide respective collimated light beams 13 which

are transmitted through the fluid 15 along parallel chords of the circular cross-section of the pipe 14, and a corresponding array of eight detectors D1 to D8 are positioned each to receive and detect a corresponding one of the transmitted beams, each of the emitters and detectors being as described with reference to Figure 1.

Alternative forms of emitter and detector array are also possible, as illustrated in Figures 3 and 4. Figure 3 shows an arrangement in which eight emitters E1 to E8 are circumferentially spaced round half the circumference of the pipe 14 and each provides a light beam 13 directed along a respective diameter, eight corresponding detectors D1 to D8 being positioned at the opposite ends of these diameters. In the arrangement shown in Figure 4, eight emitters E1 to E8 are equally spaced round the whole circumference, and likewise eight detectors D1 to D8 of which each is closely adjacent to one of the emitters and substantially diametrically opposite another of the emitters whose light beam it is positioned to intercept. Yet another arrangement is shown in Figure 5, which represents a first array of emitters E1 to E8 and detectors D1 to D8 disposed as in Figure 1, together with a second array of emitters E1' to E8' and detectors D1' to D8', similar to the first array and in the same cross-sectional plane but arranged with a angular displacement of 90° thereto. In a further elaborated arrangement indicated in Figure 6, a third array is added, disposed at 45° to both the first and second arrays, and it will be understood that a fourth array, at the remaining 45° orientation, may also be provided. The increased amount of information available from an increased number of differently oriented co-planar arrays may be desirable if it is required to reconstruct a detailed image of the distribution and sizes of inclusions 15' of a second component within the main body of the fluid in the plane being monitored.

In use of the method according to the invention, all the signal emitters are energised sequentially by application of suitable voltage pulses to each in turn. In the case of an LED,

application of short voltage pulses of, say 10μs duration, means that a higher current can be applied than if it were driven continuously and thus that it may be made to radiate with greater intensity while switched on. As shown in Figure 7, when an emitter LED is switched on by application of a voltage pulse of duration T the photodiode on which the resulting beam is focussed produces an output voltage signal which rises during the interval T to a peak from which it then falls, the value of the peak voltage being a function of the intensity incident on the photodiode and thus an inverse function of the attenuation which the radiation beam has undergone during transmission through the fluid 15.

Referring now to Figure 8, the optical signal emitters E and detectors D (one of each is shown) arrayed about the pipe 14 are under the control of an emitter multiplexer 20 and a detector multiplexer 21, these in turn being controlled by timing circuitry 22 driven by a clock 23. The emitter multiplexer 20 applies pulses of a voltage V through pulse conditioning circuitry 24 to each of the emitters E in sequence, and in response to each pulse applied to one of the emitters E the corresponding detector D produces an output voltage pulse of the form shown in Figure 7 which is amplified by a preamplifier 25 and fed into a corresponding channel of the detector multiplexer 21 and thence to a peak-detector circuit 26 which is also controlled by the timing circuitry 22. The peak-detector circuit 26 operates to capture the maximum value of each pulse from the detector multiplexer 21 and apply it to an analogue-to-digital converter 27 (also under the control of the timing circuitry 22) for a period long enough for the converter 27 to convert its analogue value into a digital number. This digital number, in the form of an 8-bit parallel digital word is then converted by a C011 interface chip 28, run in a handshaking control loop by an independent second clock 29 of 5.0 MHz frequency, into an 8-bit serial signal which is fed to the input data store of a transputer network 30 which is further referred to below. Output

signals from the peak-detector circuit 26 are fed additionally, or alternatively, via a low-pass filter 31 to a memory scope 32 and a signal analyser 33, also further referred to below.

The operation of the circuitry shown in Figure 8 and described above is further illustrated in Figure 9, in which the top curve represents a series of voltage pulses (each corresponding to that shown in the upper part of Figure 7) which are distributed by the emitter multiplexer 20 to successive emitters E. The second curve shows how, during each such pulse, the detector corresponding to the emitter to which that pulse is applied produces an output pulse corresponding to the lower part of Figure 7. These output pulses, from successive detectors, are multiplexed by the detector multiplexer 21 of which the output, as shown in the third curve, is applied to the peak-detector circuitry 26. The output signal from this latter, shown in the fourth curve, follows each pulse of the third curve up to its peak value, which it then holds for a period, and during each such hold period the analogue-to-digital converter 27 is activated by a pulse, as shown in the bottom curve, applied to it from the timing circuitry 22 to cause it to operate on the "held" value of the output signal applied to it from the peak detector circuitry 26. For simplicity, the detector output pulses are shown in the second curve of Figure 9 as being all of equal height, so that successive peaks of the signal from the detector multiplexer, shown in the third curve, are also of equal height, as also are the successive output signals from the peak detector circuitry, as shown in the fourth curve. It will be understood that this corresponds to total uniformity of the fluid cross-section being monitored, and that in practice the output signal pulses from successive detectors would be of different heights, resulting in different heights for successive peaks of the output signal from the detector multiplexer and from the peak-detector circuitry.

In a variation of this method of operation, the outputs of all the detectors in an array may be sequentially multiplexed

during the activation period of each emitter of the array. In this way information is acquired not only in respect of the attenuated signal detected by the detector corresponding directly to an activated emitter but also in respect of scattered light detected by the other detectors.

The transputer network 30 operates on the optical measurement data supplied to it to perform a reconstruction of the fluid cross-section to which the data relates, using an appropriate reconstruction algorithm dependent on the arrangement of emitters E and detectors D employed. If a full and detailed cross-sectional reconstruction is required, it is necessary to employ a plurality of multiply-intersecting arrays such as are represented in Figures 5 and 6; the transputer may then be such as to perform, in known manner, a direct Fourier reconstruction using fast Fourier transformation of the data derived from the multiple arrays, or alternatively fast Hartley transforms or the simpler back-projection algorithm may be used. Alternatively, less detailed but still useful reconstructions may be obtained by the use of appropriate algorithms on data derived from simpler data-acquisition arrays such as are represented in Figures 2, 3 and 4.

Alternatively, or additionally, useful information regarding the fluid-flow regime of the fluid being monitored can be obtained by means of the signal analyser 33 operating on data acquired by means of a relatively simple array of emitters and detectors, or even by repeated pulsing of only a single emitter-detector pair. Three types of fluid-flow regime which may be readily distinguished may be termed respectively bubble flow, churn flow and plug flow: "bubble flow" meaning a relatively smooth flow of a main body of a first component of the fluid which, however, contains a random distribution of "bubbles" or other inclusions of a second component, "churn flow" indicating flow which includes a turbulent or swirling motion, and "plug flow" meaning flow in which there occur, in a main component of the fluid, bubbles or other inclusions of a second

component which are so large that they occupy the whole or a substantial proportion of the cross-section of the pipe and extend over a significant distance longitudinally of the pipe. Even a single emitter-detector pair, as shown in Figure 1, if pulsed repeatedly will provide a train of pulses of which the amplitude varies with time in a way characteristic of the type of flow regime, and frequency analysis of such a train of pulses by means of the signal analyser 33, by the use of built-in Fast Fourier Transform programs, enables the frequency spectrum to be established and thereby the type of flow regime to be identified, since different flow regimes produce distinctively different frequency spectra. The useful flow-regime information for this purpose will usually be contained within a frequency range having an upper limit of approximately 500 Hz, and it is therefore convenient to limit the signal supplied to the signal analyser 33 by passing it through the low pass filter 31, shown in Figure 9, having a bandwidth from d.c. to 1 KHz.

In all the foregoing description, the arrays of signal emitters and detectors are located at a single cross-sectional plane of the pipe 14. In order to monitor the flow velocity of fluid along the pipe, and thus to establish the volume flow rate of the fluid as a whole (and of its components when the proportions of these have been established by the monitoring described above), a further array of signal emitters and detectors may be provided at a second cross-sectional plane of the pipe, spaced downstream of the pipe from the first. Such an arrangement is shown in Figure 10, in which the pipe 14 is provided at a first cross-sectional plane with a first array of signal emitters and detectors, schematically represented in the Figure by an emitter E and a detector D, which may be as described above with reference to any of Figures 2 to 6, and also, at a second cross-sectional plane spaced downstream from the first in the flow direction 34 of the fluid 15 with inclusions 15', with a further array, preferably identical with the first, as schematically represented in the Figure by an

emitter E' and a detector D'. Data relating to a reconstructed cross-sectional image derived from data acquired by the E', D' array at the second plane may then be compared with stored data relating to each of a series of stored images derived from data acquired by the E, D array at the first plane at known earlier times in order to establish identity or near-identity with one of those earlier images, the known time lapse between the two near-identical images then giving a measure of the transit time of fluid from the one plane to the other and thus of the fluid flow rate.

Although only LEDs have been specifically referred to above as suitable sources for the collimated beams transmitted through the fluid being monitored, it will be appreciated that other suitable types of source are available for the purpose. In particular, the falling cost of laser diodes, and their greater optical output, may well lead to their use in place of LEDs, especially in connection with larger diameter pipes or where the fluid being monitored or a substantial component thereof is of low optical transmissivity.

In a further development of the invention it is possible to use two sets of emitter-detectors operating at different wavelengths for monitoring 3-component flows such as oil, water and air. One wavelength may be chosen to be attenuated by oil but transmitted through water, thus enabling a cross-section which determines the distribution of oil. The second wavelength may then be chosen to be attenuated a similar amount in oil but to be also attenuated by the water. Thus a second cross section determining the distribution of oil and water would be obtained. Comparison of the two cross sections would enable distribution of water to be obtained.

CLAIMS

1. A method of monitoring flow of a fluid having at least two components, comprising transmitting a train of signal pulses in at least one beam transversely through the fluid flow to be monitored, detecting the pulses after attenuation thereof by transmission through the fluid and deriving a train of output pulses corresponding to the detected attenuated pulses, and deriving from the output signals data relating to the configuration of the flowing fluid where subjected to the signal pulses.

2. A method as claimed in Claim 1, and including the step of performing a frequency analysis on the train of output pulses to establish the frequency spectrum thereof and thereby identify the type of flow regime of the fluid.

3. A method as claimed in Claim 1 in which the signal pulses are transmitted in a plurality of at least approximately collimated signal beams across a transverse cross-section of the flowing fluid, the method including the further steps of detecting the signal beams after attenuation thereof during passage through the fluid and deriving output signals related to the attenuated signals received, storing the output signals and deriving therefrom tomographic data relating to the instantaneous spatial configuration of the flowing fluid at the said cross-section thereof.

4. A method of monitoring the velocity of a flowing fluid, comprising the steps of carrying out the method of Claim 3 repeatedly at each of two transverse cross-sections of the fluid at two locations spaced from one another in the direction of flow, including deriving and storing output signals and tomographic data derived therefrom relating to sequences of timed reconstructed cross-sectional images for the two locations, recognising identity or near-identity between data relating to an image for one of the locations and data relating to an image for the other of the locations, and establishing the time lapse between the timing of the two corresponding images as a measure

of the transit time of the fluid between the two locations and hence of the flow velocity.

5. A method as claimed in any of Claims 1 to 4, wherein the said signal pulses are pulses of visible or near-visible light.

6. Fluid flow monitoring apparatus comprising means for transmitting a train of signal pulses in at least one beam transversely through the flow of fluid to be monitored, means arranged to detect the pulses after attenuation thereof by transmission through the fluid and to provide a train of output pulses related to the attenuated pulses received, and means for deriving from the output signals data relating to the configuration of the flowing fluid.

7. Monitoring apparatus as claimed in Claim 6 and comprising frequency analyser means arranged to analyse the train of output pulses and establish the frequency spectrum thereof, thereby to identify the type of flow regime of the fluid.

8. Monitoring apparatus as claimed in Claim 6 and comprising a plurality of means for transmitting at least approximately collimated signals across a transverse cross-section of a pipe or duct containing a flowing fluid and a plurality of signal detector or sensor means arranged to detect said signals after attenuation thereof during passage through the fluid and to provide an output signal related to the attenuated signal received, multiplexing means arranged to scan the detector means sequentially and supply the said output signals therefrom to data storage means, and transputer means connected to receive and arranged to process the data stored in the data storage means and derive therefrom tomographic data relating to the instantaneous spatial configuration of the flowing fluid at the said cross-section of the pipe or duct.

9. Apparatus for monitoring the velocity of a fluid flowing through a pipe or duct, comprising, at each of two locations spaced from one another lengthwise of the pipe or duct, a respective plurality of means for transmitting at least approximately collimated signals across a transverse

cross-section of the pipe or duct and a respective plurality of signal detector or sensor means arranged to detect said signals after attenuation thereof during passage through the fluid and to provide output signals related to the attenuated signals received, multiplexing means arranged to repeatedly scan the detector means sequentially and supply the said output signals therefrom to data storage means, transputer means connected to receive and arranged to process the data stored in the data storage means and derive therefrom tomographic data relating to sequences of timed reconstructed cross-sectional images for the two locations, and means for comparing, and recognising identity or near-identity between, data relating to an image for one of the locations and data relating to an image for the other of the locations and for establishing the time lapse between the timings of the two corresponding images as a measure of the transit time of the fluid between the two locations and hence of the flow velocity.

10. Apparatus as claimed in any of Claims 6 to 9, wherein the signal-pulse transmitting means comprise one or more light-emitting diodes or laser diodes.

11. Apparatus as claimed in any of Claims 6 to 10, wherein the signal-pulse transmitting means are adapted to emit visible or near-visible light.

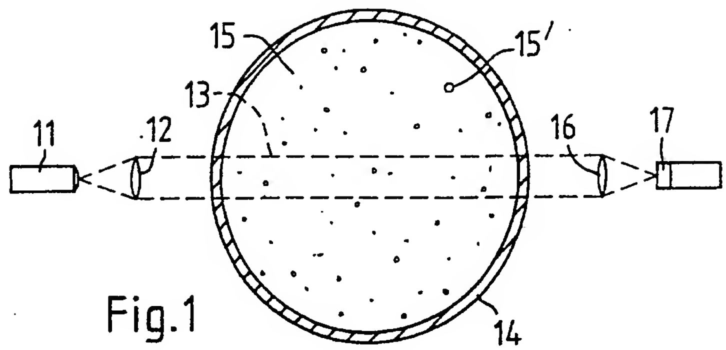


Fig.1

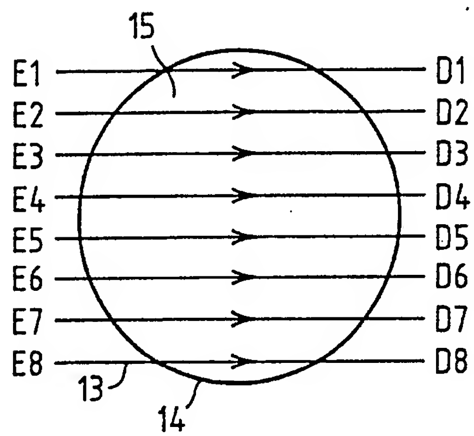


Fig.2

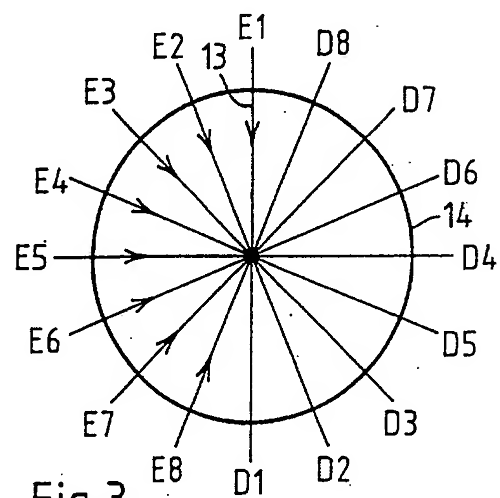


Fig.3

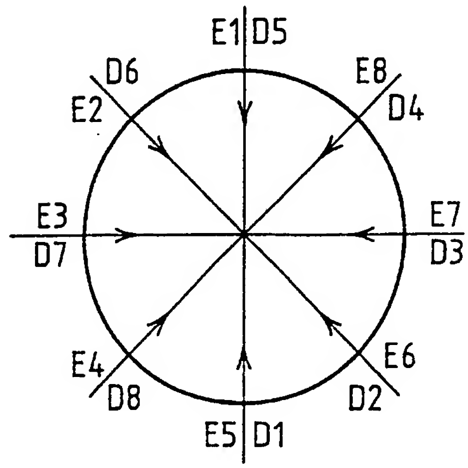


Fig.4

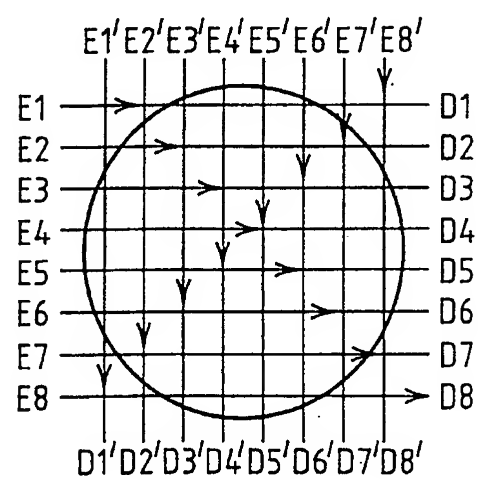


Fig.5

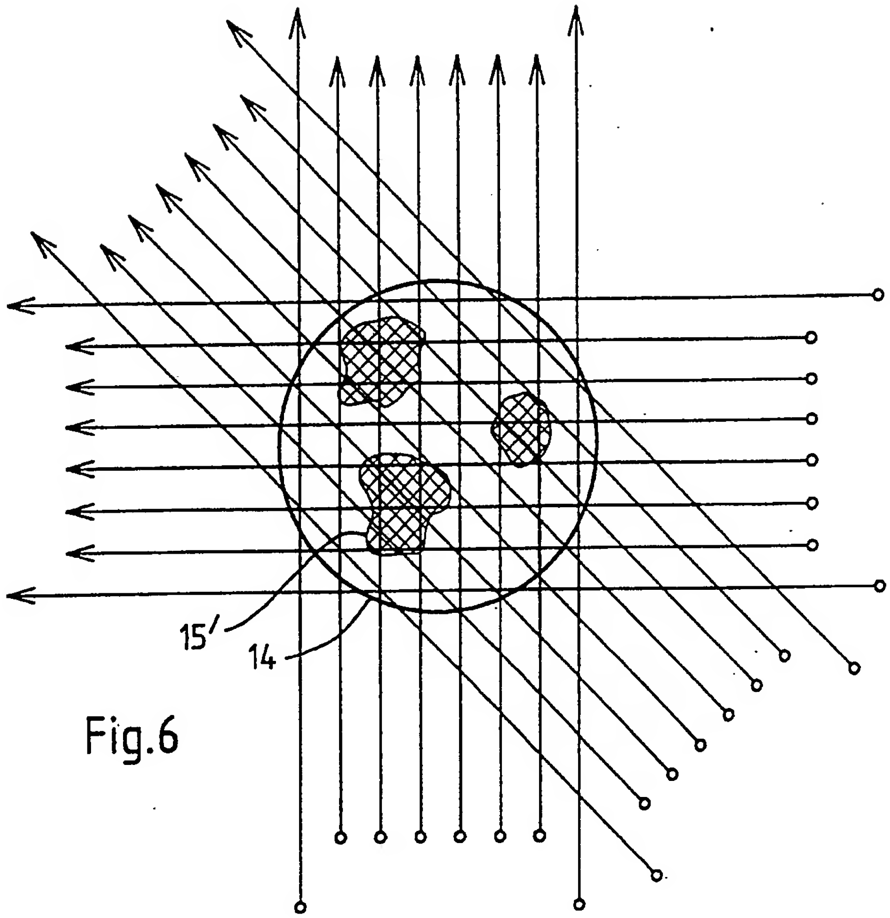


Fig.6

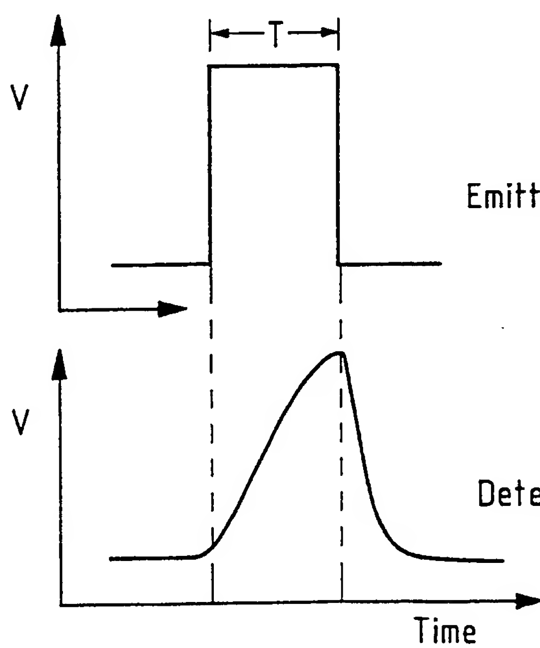
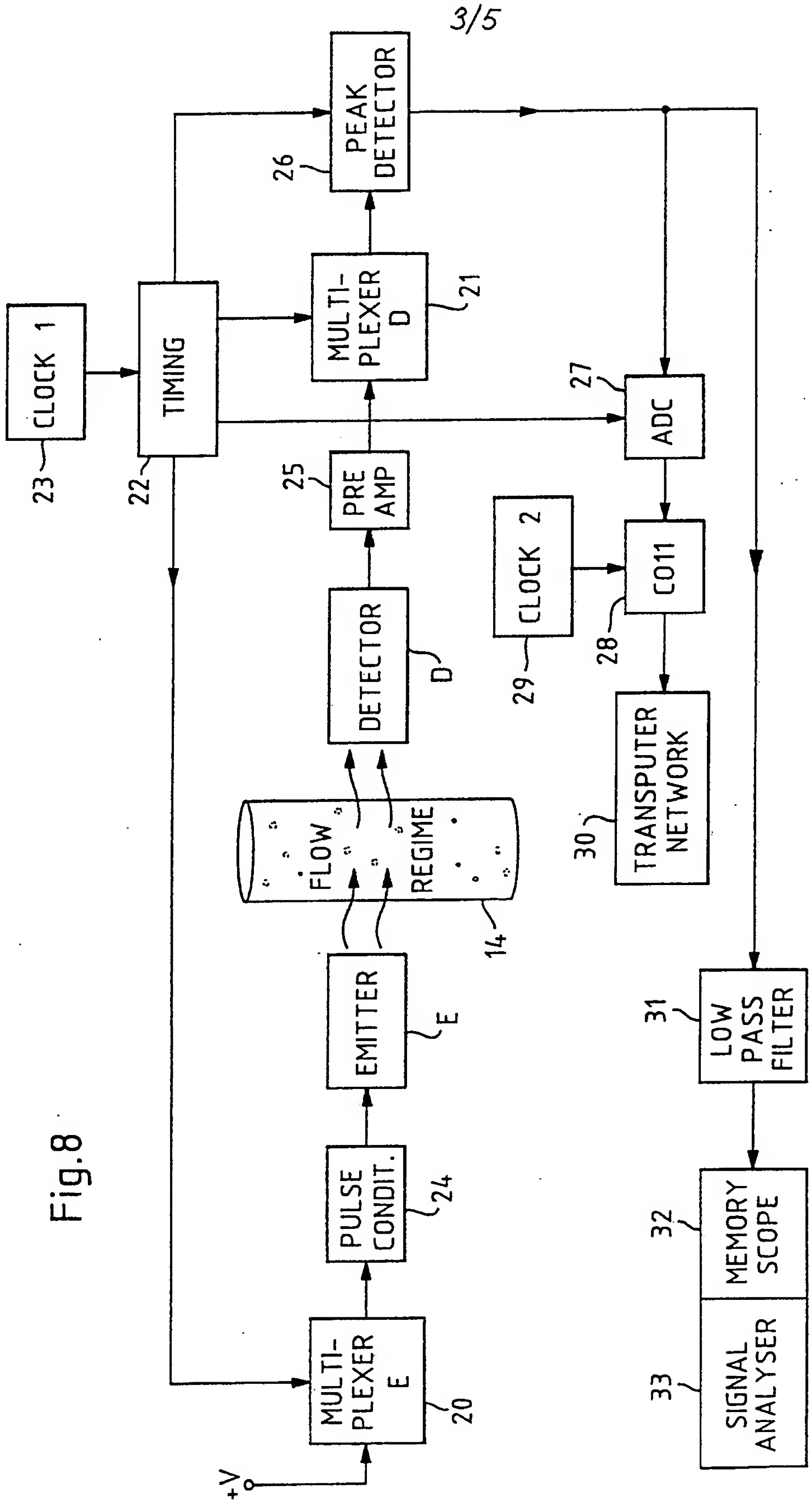


Fig.7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24
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20
+V
ADC
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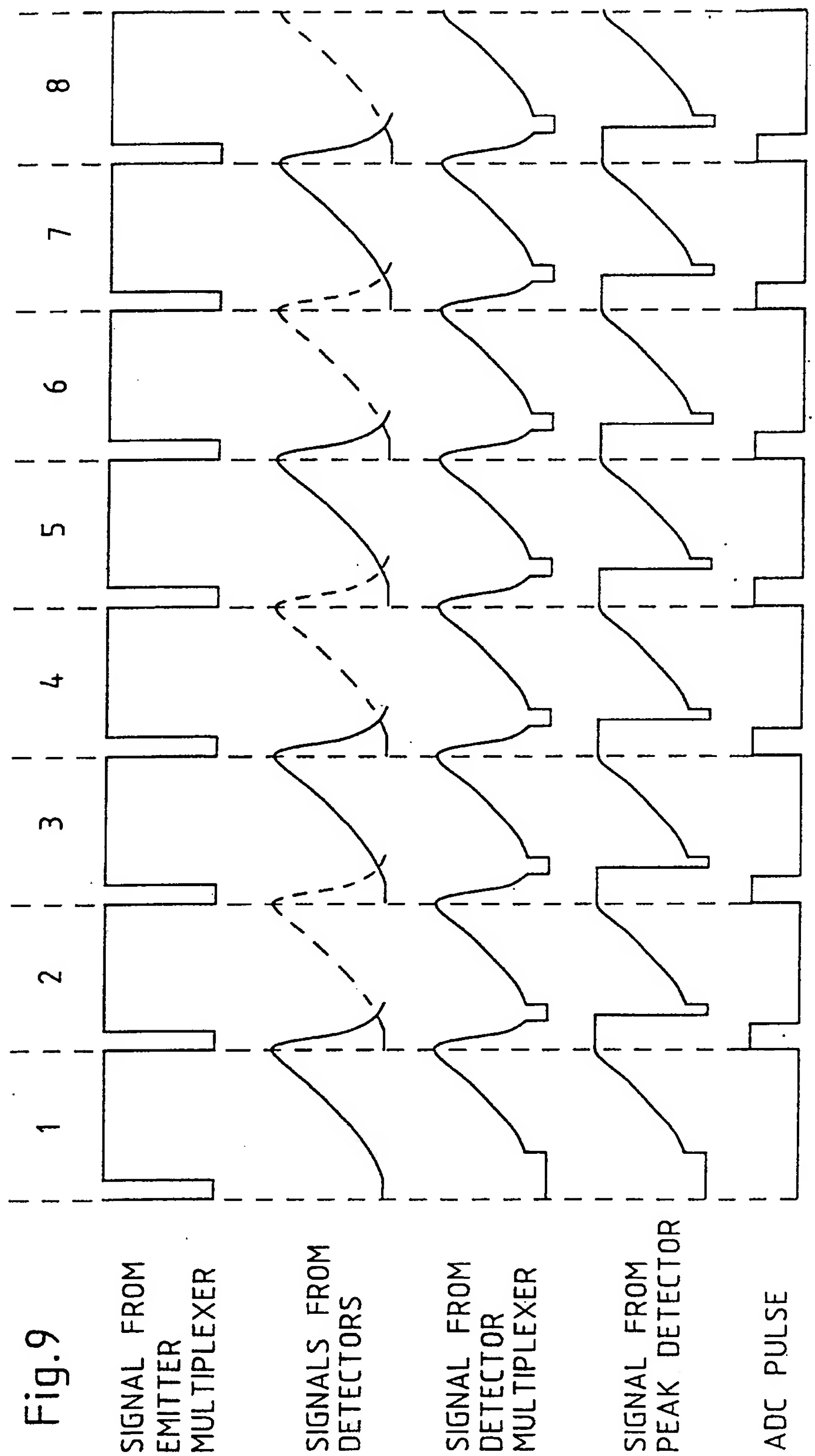
Fig.8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SIGNAL FROM PEAK DETECTOR
ADC PULSE

Fig.9

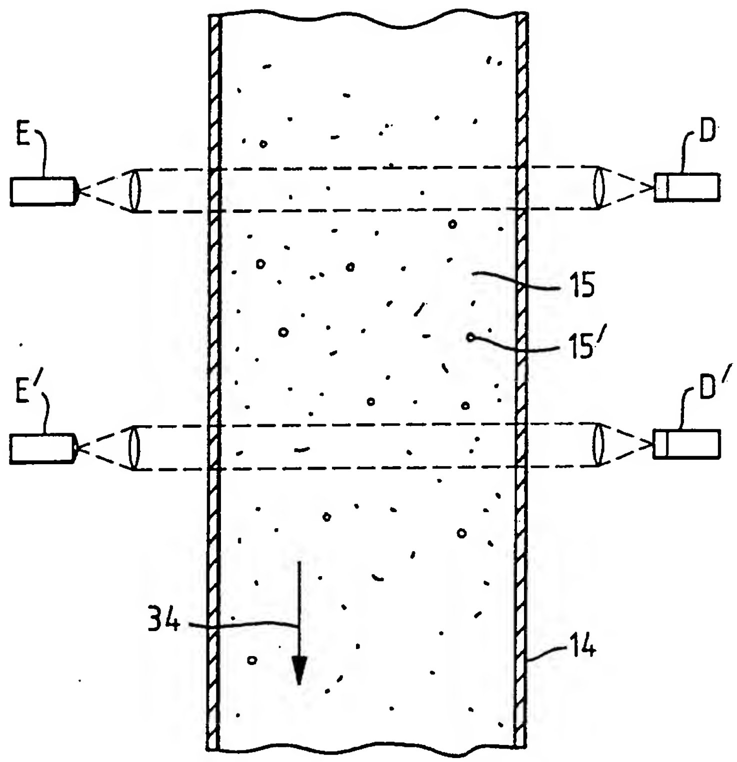

Fig.10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00786

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.5 G 01 N 21/85 G 01 F 1/74 G 01 N 23/12

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl.5	G 01 N G 01 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US-A-4 228 353 (S.A. JOHNSON) 14 October 1980, see figure 1; column 3, line 59 - column 4, line 62; column 13, line 15 - column 14, line 20; claims 1,2,4,17 ---	1,3,5,6,11
X	GB-A-2 219 396 (COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION) 6 December 1989, see claims 1,2,13,14 ---	1,4,6,9
A	GB-A-2 116 699 (ITT INDUSTRIES LTD) 28 September 1983, see claims 1-6,9,15,16 ---	1,2,6,7
A	EP-A-0 364 083 (DICKEY-JOHN CORP.) 18 April 1990, see claim 1; column 4, lines 48-57; column 6, lines 5-41 --- -/-	6,10,11

° Special categories of cited documents : [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
24-08-1991	19. 09. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. PEIS M. Peis

International Application No PCT/GB 91/00786

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	EP-A-0 026 093 (THE BRITISH PETROLEUM CO.) 1 April 1981, see claim 1 ---	6
A	US-A-4 809 543 (L. BAILLIE) 7 March 1989 -----	

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. GB 9100786
SA 47476

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 13/09/91
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4228353	14-10-80	None	
GB-A- 2219396	06-12-89	US-A- 5025160	18-06-91
GB-A-.2116699	28-09-83	None	
EP-A- 0364083	18-04-90	US-A- 4931774 AU-A- 3992689	05-06-90 22-02-90
EP-A- 0026093	01-04-81	None	
US-A- 4809543	07-03-89	None	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82